Armed Forces College of Medicine

AFCM

Urine Concentration & Dilution

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1. Mention mode of **handling of water** along nephron.
2. Discriminate **obligatory** and **facultative** water reabsorption.
3. Define the **countercurrent** system.
4. Describe the **renal countercurrent system**, its components and importance.
5. Explain the role of **loop of Henle** of juxta medullary nephrons in creating an osmotic gradient in the medullary interstitium (the countercurrent multiplication system).
6. Discuss the role of **vasa recta** as countercurrent exchanger in maintaining the hyperosmolarity of the medullary interstitium.
7. Explain how **urea** reabsorption contributes to the hyperosmotic renal medullary interstitium.
8. Describe the role of regional distribution of **renal blood flow** in creating hyperosmolarity of the medullary interstitium.
9. Explain how the kidneys produce **concentrated** or **diluted** urine.
10. Distinguish **water diuresis** from **osmotic diuresis**.

Renal handling of

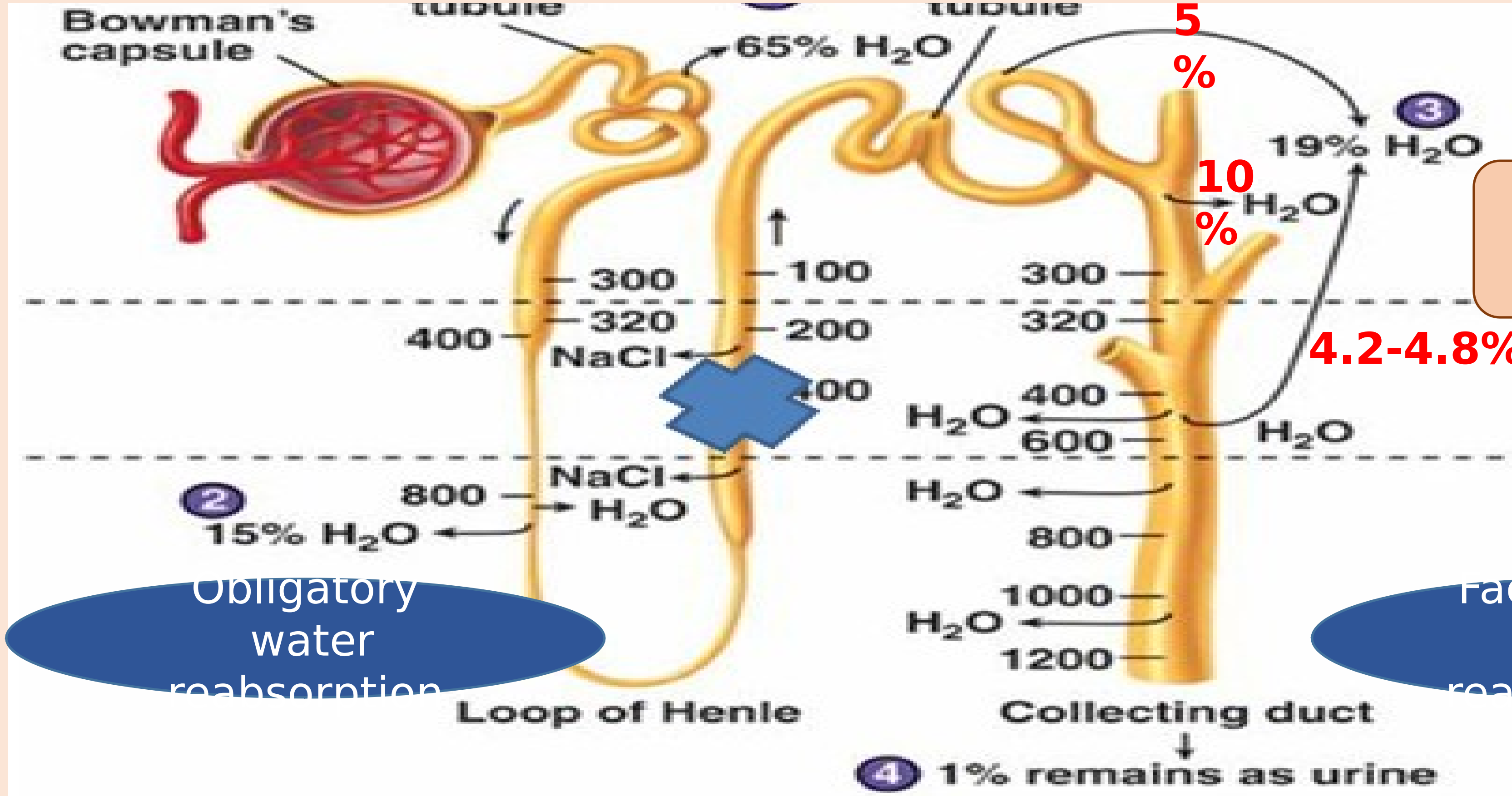
- **All** parts of the nephron is permeable to water except ~~ascending limb of LH~~.

absorbed **passively** by **osmosis**.

-GFR: 125 ml/min
So, daily **filtered** volume of water
125 X 60 X 24 = 180.000 ml/day = 180 L/ day.

-99.2-99.8 % of filtered water will be **reabsorbed** = 178.5-179.5 L/day.
-**Not secreted**.

-0.2-0.8% of filtered water



5 %

10 %

4.2-4.8%

ADH

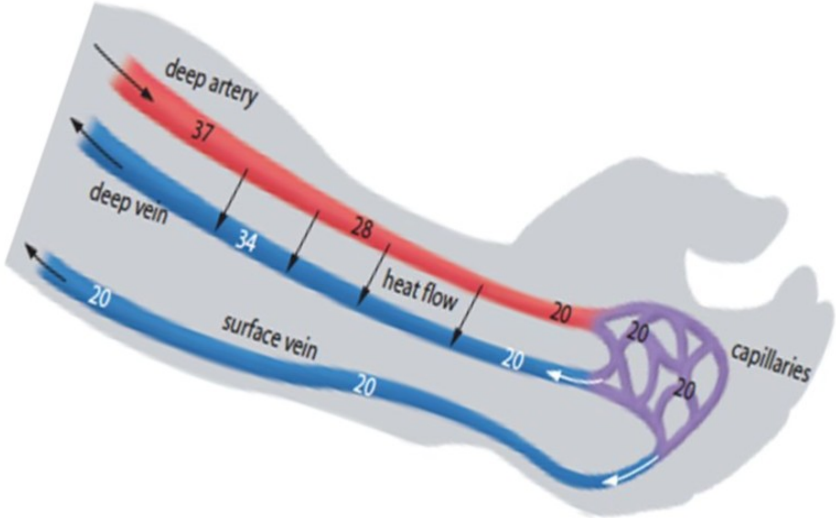
Obligatory water reabsorption

Facultative water reabsorption

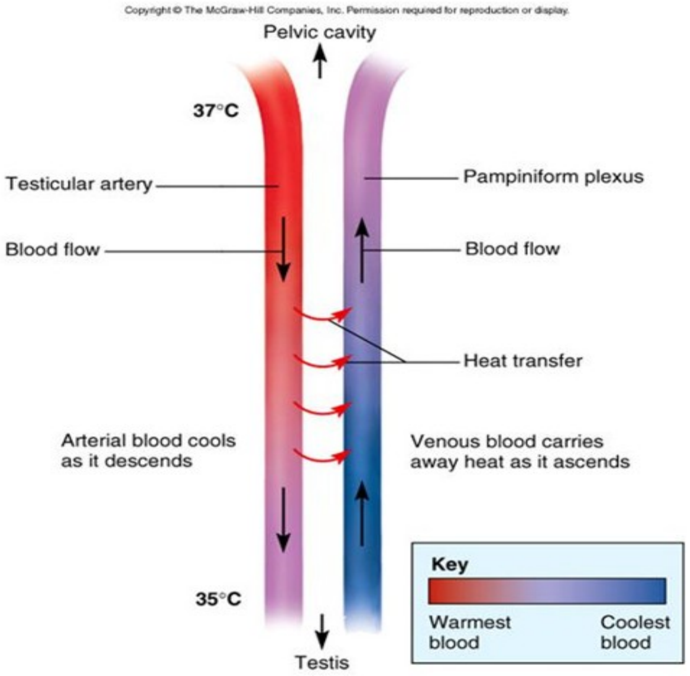
Daily urine output: 0.5-1.5 L / day

Countercurrent system

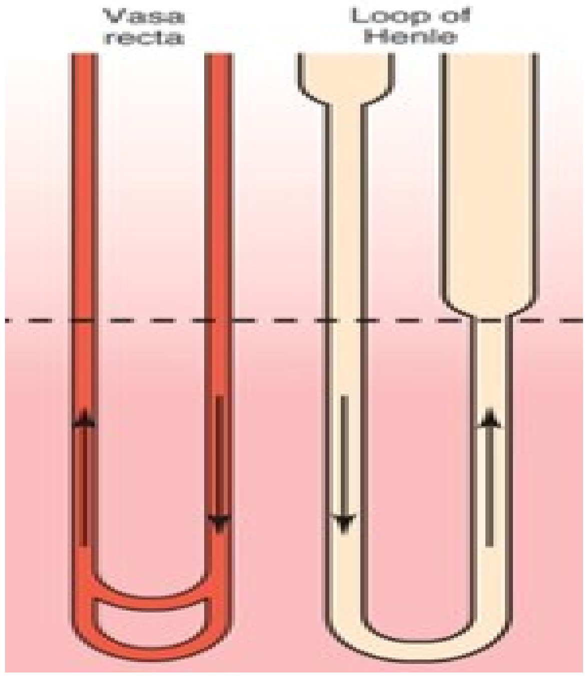
Is a system where there are **2 currents** flowing **opposite, parallel** and **in close proximity** to each other



Skin countercurrent (thermoregulation)
Exchange



Testicular countercurrent (37 °C 32-35°C for spermatogenesis)
Exchange

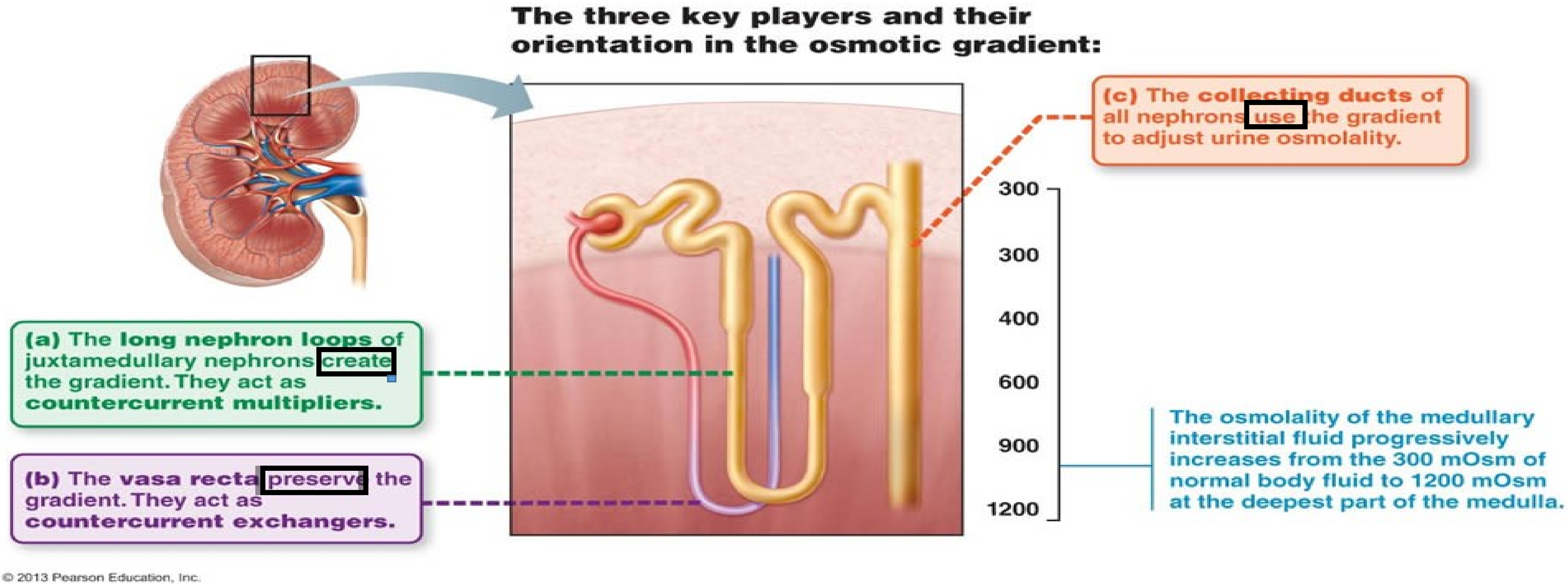


Renal countercurrent (urine
Exchanger,

Renal countercurrent

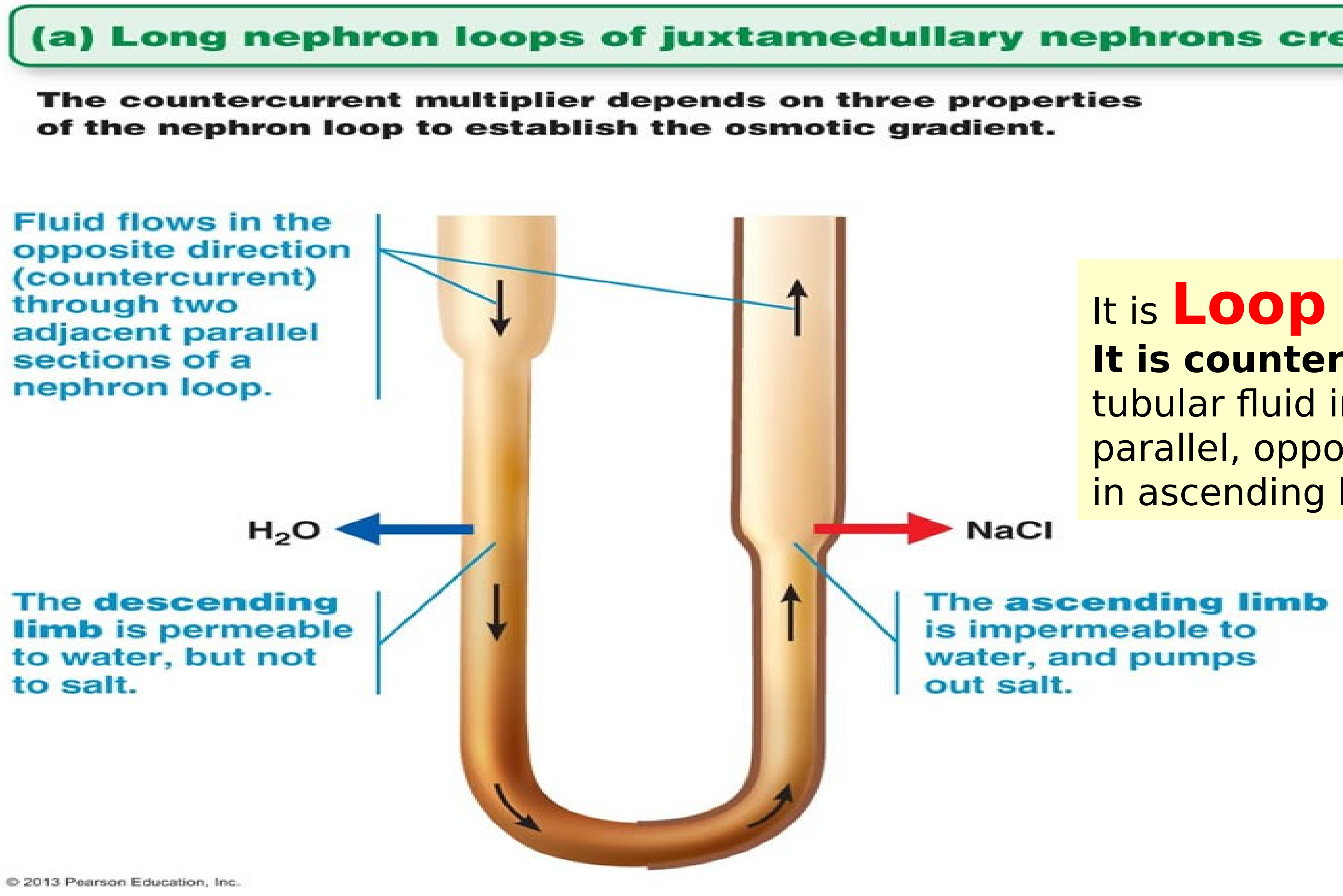
Aim: Urine Concentration

Components: 3



1- Countercurrent multiplier system

(Active System)



It is **Loop of Henle**

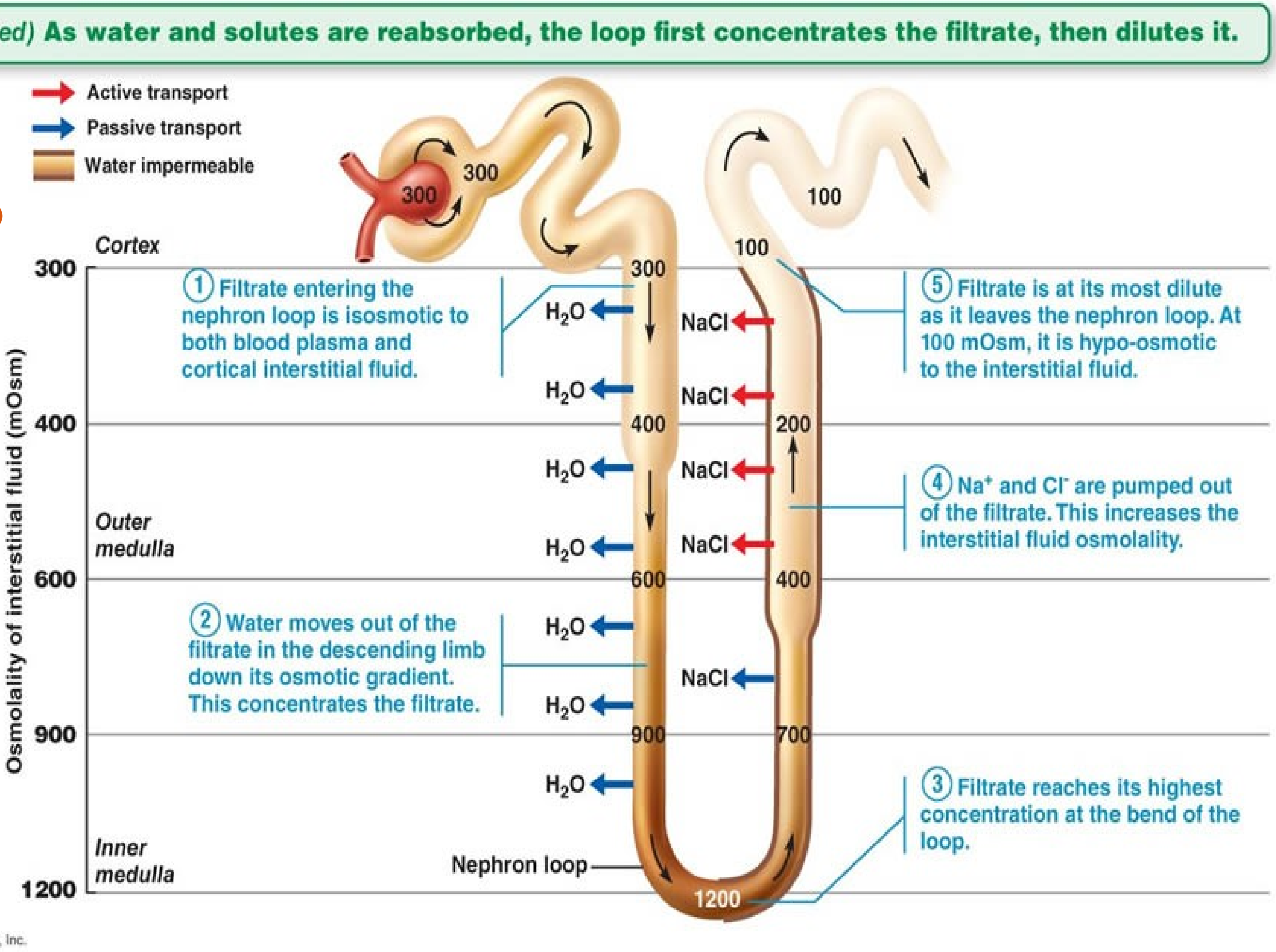
It is countercurrent: as the flow of tubular fluid in the descending limb is parallel, opposite, adjacent to its flow in ascending limb

1- Countercurrent multiplier system

(Active System)

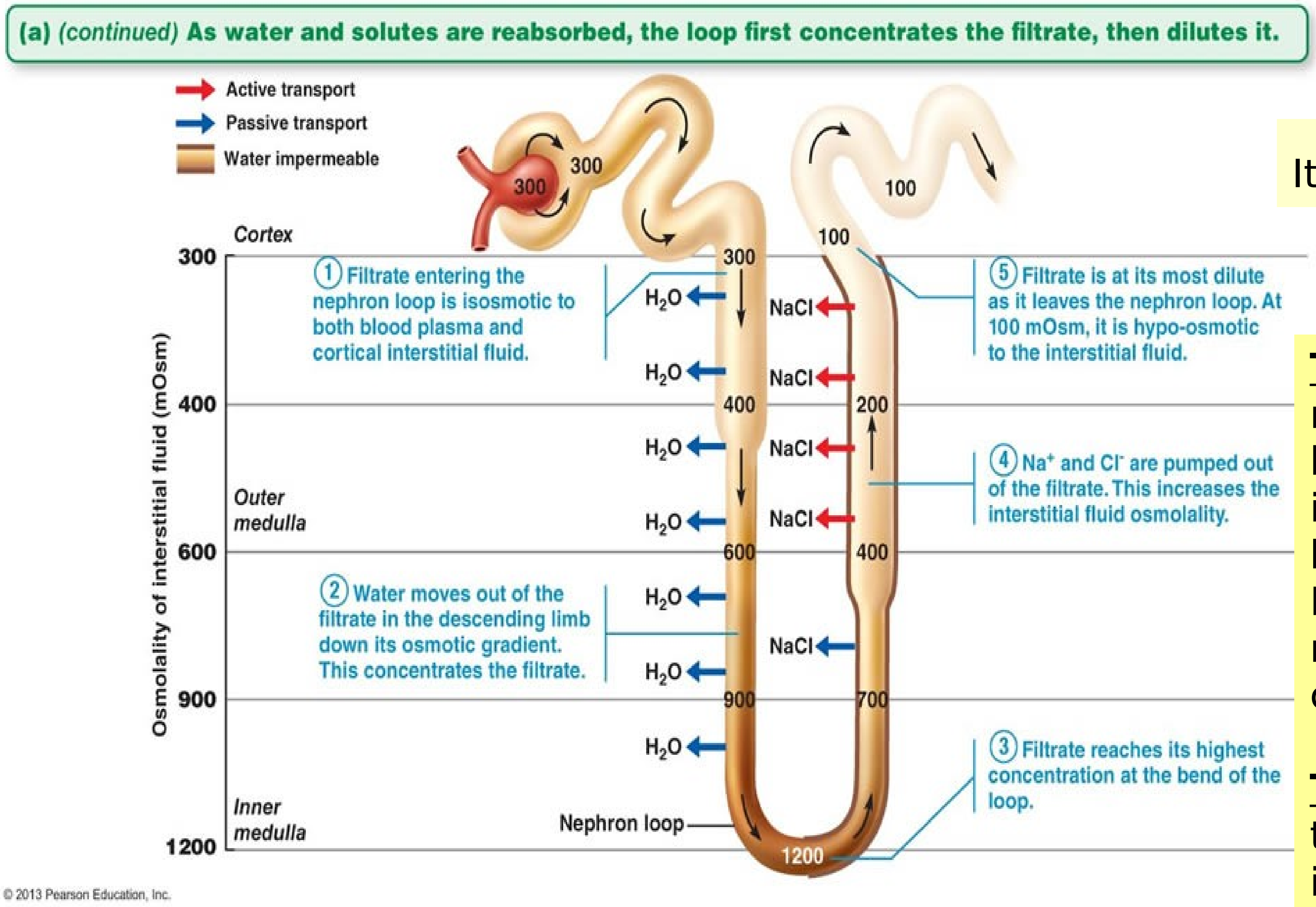
It is **Loop of Henle**

It is multiplier: as it causes the medullary interstitial osmolarity to be multiplied from cortex (**300mOsm/L**) to renal papillae (**1200-1400 mOsm/L**) by throwing NaCl out in the medullary interstitium.



1- Countercurrent multiplier system

(Active System)



It is **Loop of Henle**

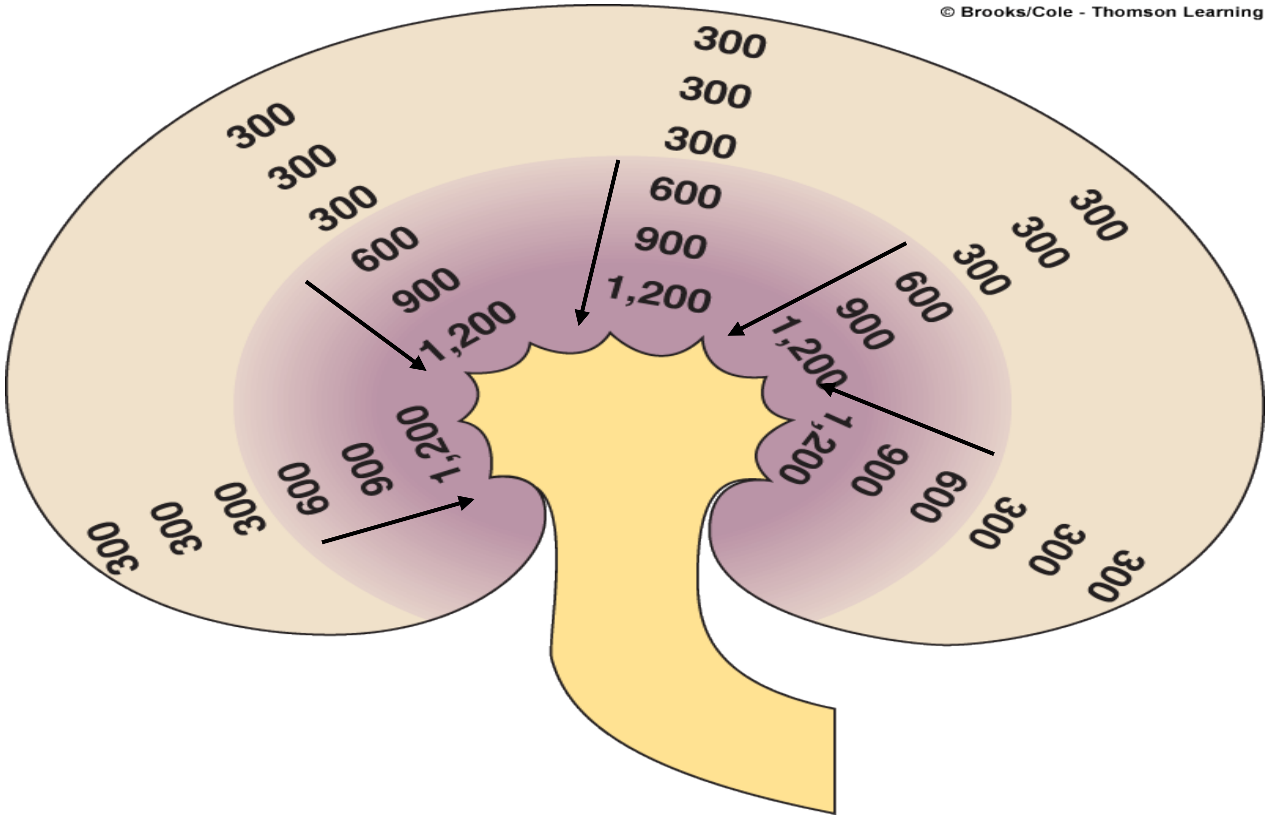
Mechanism

<u>Thin ascending limb</u>: filtrate reach the thin ascending limb is hypertonic (1200 mOsm/L) as water is reabsorbed from the descending limb concentrating NaCl inside. So, NaCl diffuses passively to the medullary interstitium under concentration gradient.

<u>Thick ascending limb:</u> Actively transport NaCl into the medullary interstitium using Na^{+}-K^{+}- $2Cl^{-}$

1- Countercurrent multiplier system

Function: Building up medullary interstitium graded hyperosmolarity



https://quizlet.com/181623713/118_countercurrent-exchange-function-of-the-vasa-recta-micturition-flash-cards/

1- Countercurrent multiplier system

(Active System)

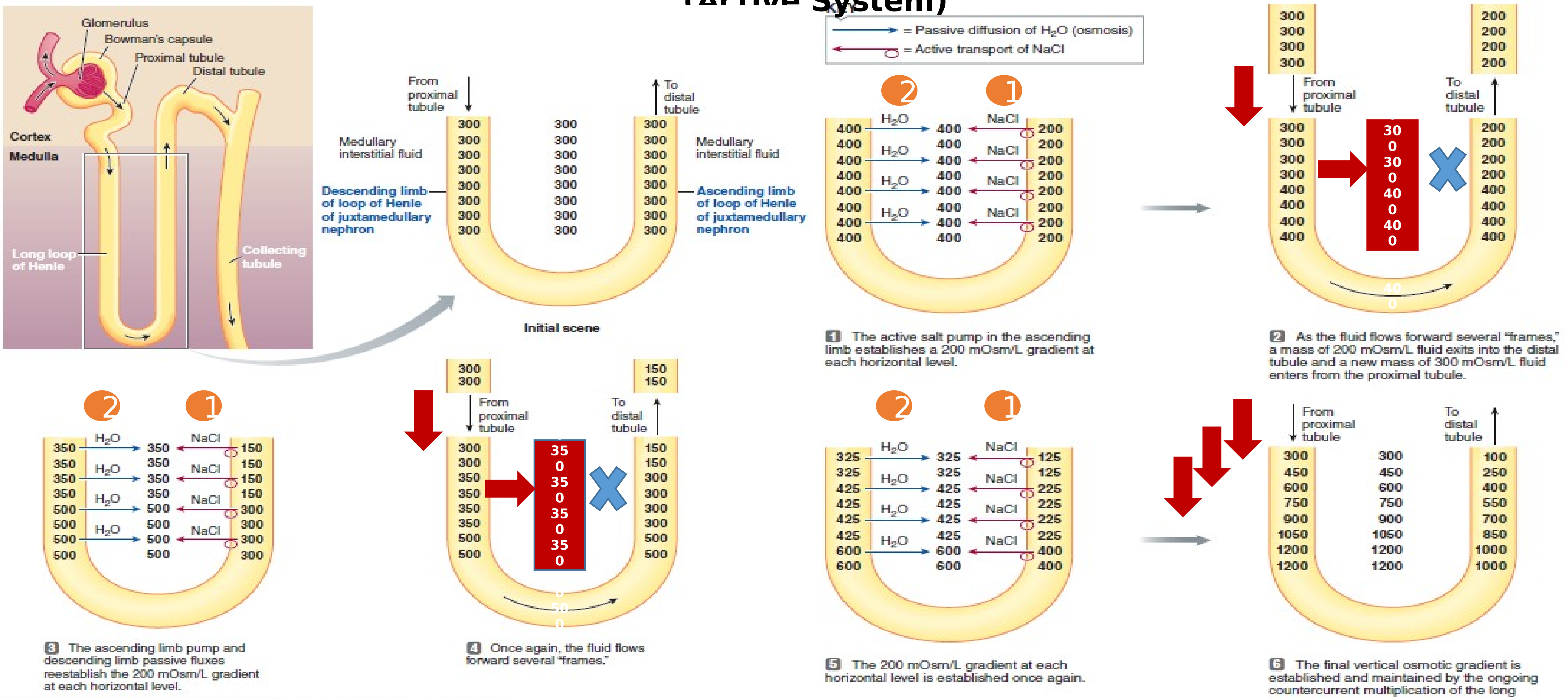
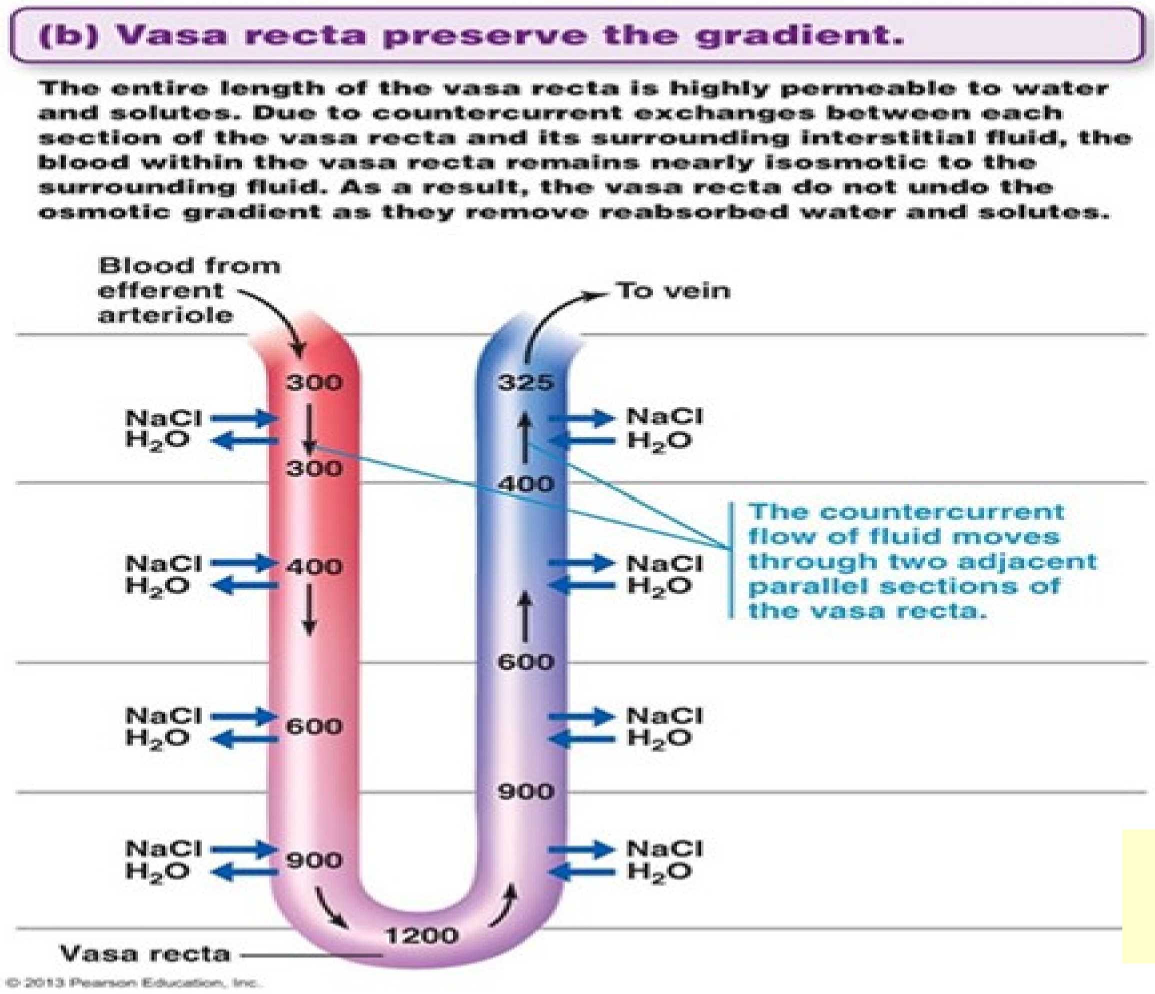


Figure 14-25 **Countercurrent multiplication in the renal medulla.** All values are in mOsm/L.

2- Countercurrent exchanger system

(Passive system)



It is **Vasa recta (VR)**

It is countercurrent: as the flow of blood in its descending limb is parallel, opposite, adjacent to its flow in ascending limb

It is exchanger: as it exchanges water and salts along its ascending and descending limbs:

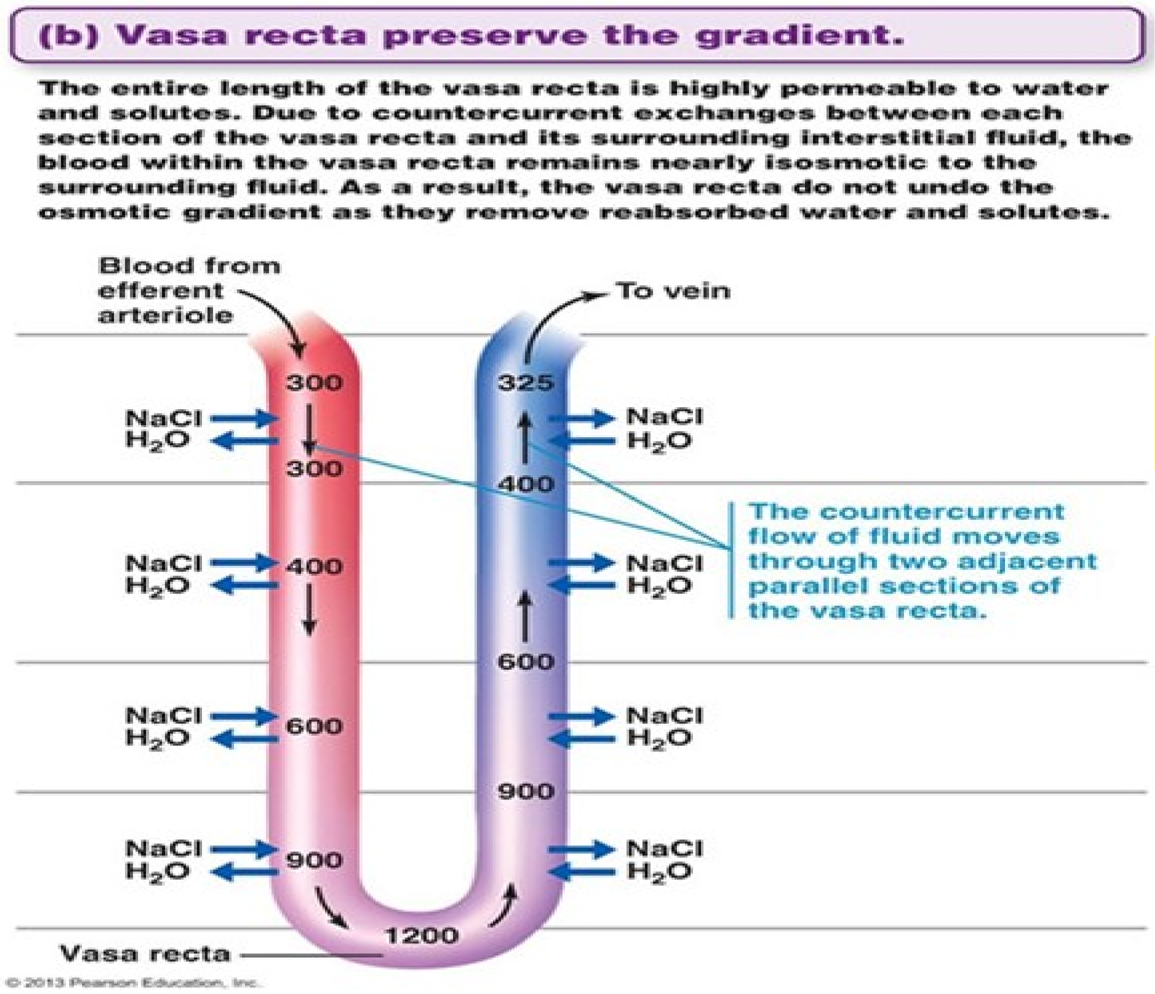
Descending limb: water passes from VR to interstitium , while salts passes from interstitium to VR blood gradullaly increasing its concentration inside.

Ascending limb: water passes from interstitium to VR , while salts passes from VR blood to interstitium gradullaly decreasing its concentration inside.

Function: Maintain medullary interstitium graded hyperosmolarity

2- Countercurrent exchanger system

(Passive system)

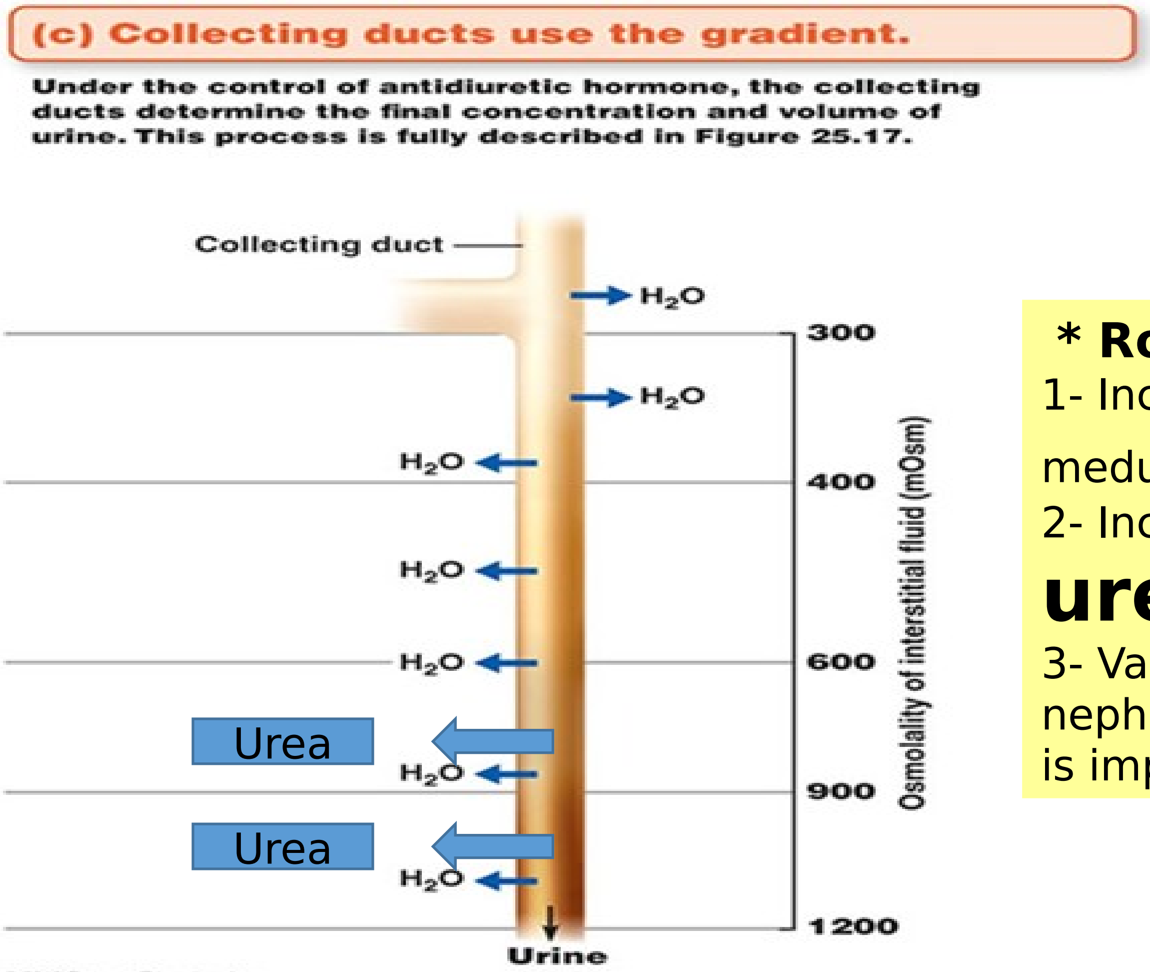


It is **Vasa recta**

Mechanism

1-**Keeping salts in the interstitium**
2-**Removing water from the interstitium**

3- Medullary collecting duct



Mechanism

ADH

*** Role of ADH in urine concentration:**

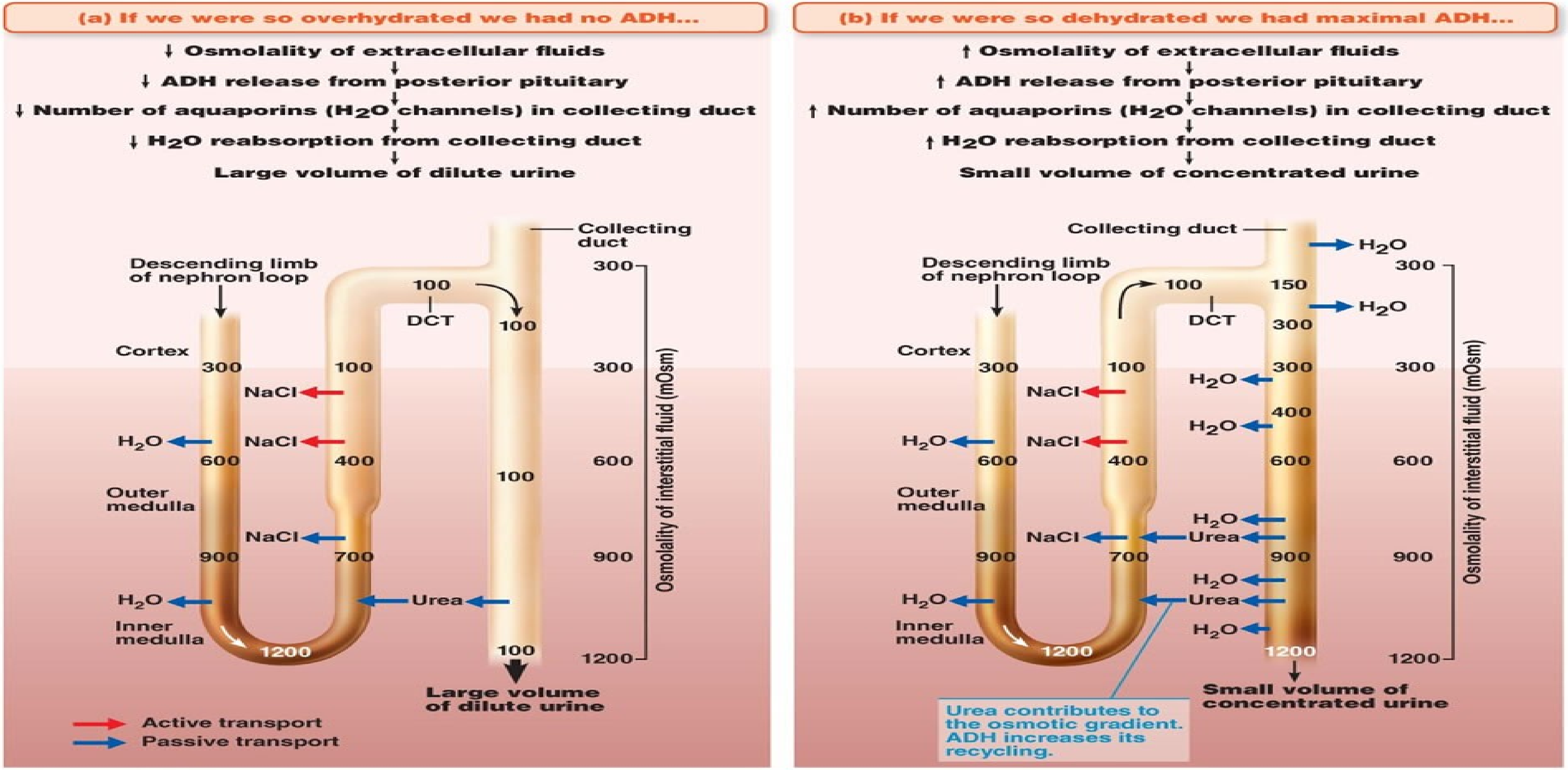
1- Increases the permeability of late DCT, CD (cortical, medullary portions) to **water**.

2- Increases the permeability of the inner medullary CD to **urea**.

3- Vasoconstriction of efferent arteriole of juxtamedullary nephrone, decreases the blood flow in vasa recta (sluggish flow is important for urine concentration)

Function: Establishment of osmotic equilibrium between tubular fluid and medullary interstitium

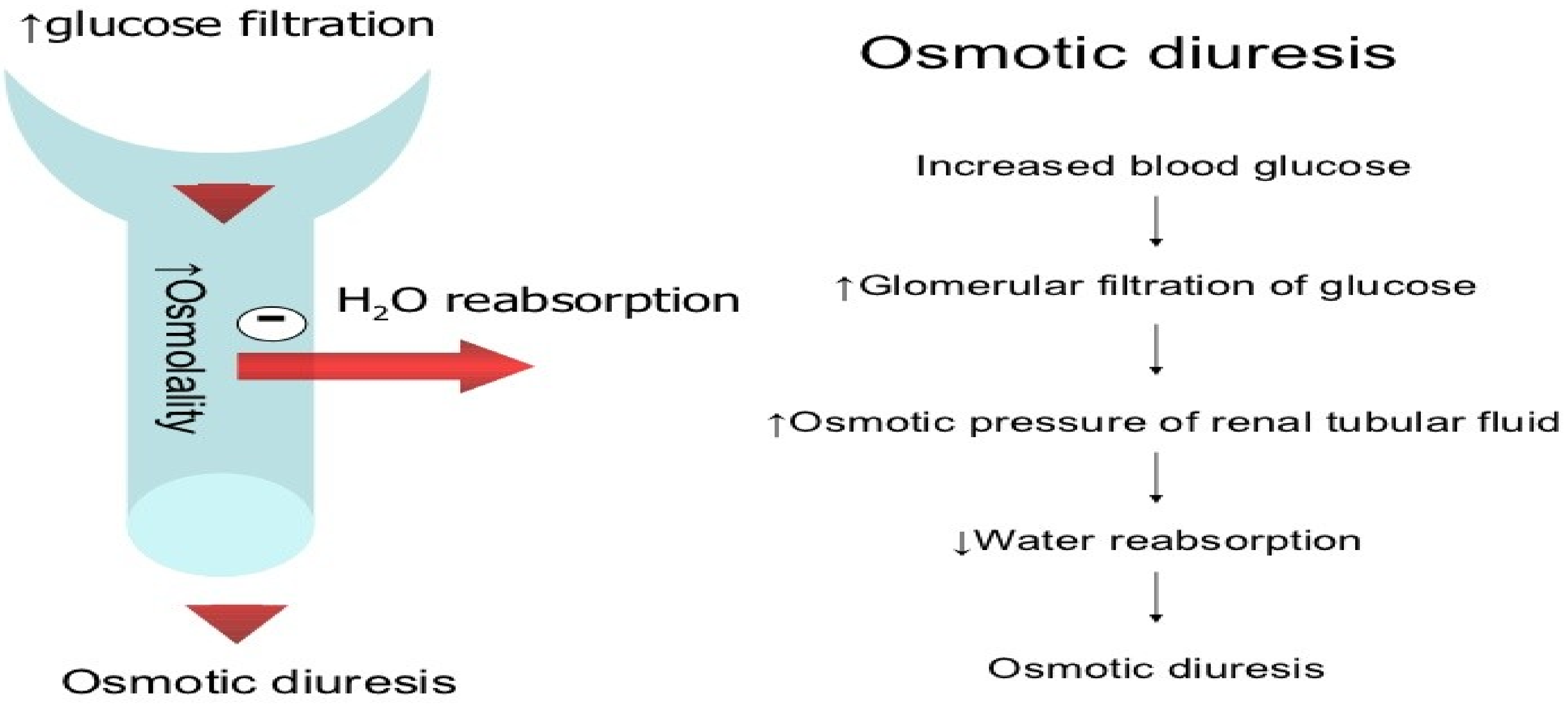
Urine dilution and concentration



In absence of ADH
= **urine dilution**

In presence of ADH
= **urine concentration**

Osmotic Diuresis



https://www.stepwards.com/wp-content/uploads/2016/02/body-fluid-and-electrolyte-balance-59-728.jpg

Water and Osmotic Diuresis

Water Diuresis	Osmotic Diuresis
Increased urine flow rate (no change in solute excretion) = increased pure water excretion	Increase in urine flow rate as well as increased solute excretion.
• **Causes:** - Excess ingestion of water - Lack of ADH (neurogenic **Diabetes Insipidus**) - Defect in ADH receptors in Distal segment of nephron (nephrogenic Diabetes Insipidus)	• **Causes:** - Increase plasma glucose level (**Diabetes Mellitus**) - **Diuretic** drugs (e.g. Lasix)
• Diuresis is mainly due to decrease in water reabsorption in distal segment of nephron (affect **facultative** water reabsorption). • No change to the water reabsorbed proximally	• Decrease solute reabsorption results in decrease in water reabsorption proximally as well as distally (affect both **obligatory and facultative** water reabsorption)
• Urine osmolality falls far below plasma osmolality.	• Urine osmolality falls but remains above plasma osmolality.
• Only about 20% filtered load of water reaching distal segments may remain unabsorbed and excreted in urine	• Due to decreased water reabsorption in all segments of nephron, a much greater fraction of filtered water may be excreted
• ADH administration will stop diuresis if it is due to lack of ADH or excess ingestion of water. ADH administration will not be effective in Nephrogenic Diabetes Insipidus.	• ADH administration will NOT stop diuresis.

Lecture Quiz

Q: Complete:

-The daily obligatory H_2O reabsorption is about………

-The daily minimum volume of obligatory H_2O loss that must accompany excretion of wastes is……….

Q:Discuss role of ADH in concentrating urine

Q:Mention the requirements for urine concentration

SUGGESTED TEXTBOOKS

1. **Sherwood Textbook of Medical Physiology**
2. **Linda Costanzo Textbook of Medical Physiology**